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POLYNUCLEAR AROMATIC HYDROCARBONS IN
AIRBORNE PARTICULATE COLLECTED ON ANDERSEN FILTERS
IN SAULT STE. MARIE

by:

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ABSTRACT

A preliminary investigation was conducted on the distribution of certain polynuclear aromatic hydrocarbons in airborne particulate in the vicinity of the Algoma Steel Company at Sault Ste. Marie. By the analysis of Andersen filter samples, it was shown that these compounds, including the carcinogenic benzo(a)pyrene were associated mainly with the "respirable" portion of air particulate in that area. A comparison with results from a previous study on this subject for the Hamilton area revealed very similar particle size distribution for these contaminants in both cities.

INTRODUCTION

An exploratory sampling programme of airborne particulates in Sault Ste. Marie has been initiated by Northeastern Region for the purpose of investigating the distribution of polynuclear aromatic hydrocarbons (PAH) with particle size. The interest in such investigation at Sault Ste. Marie originated primarily from the Algoma Steel Company being located in this area, where coke-oven stack gases, containing PAH, are emitted into the atmosphere.

A similar study (Report OTC-230177) for the Hamilton area with its local steel mills (Steel Company of Canada and Dominion Foundries and Steel Company) has shown that PAH compounds were predominantly associated with particles in the "respirable" size range. Relatively high levels of PAH have frequently been found in the atmospheres of both Hamilton and Sault Ste. Marie by the analysis of High Volume filters exposed in these areas. In view of the known carcinogenicity of some PAH compounds, particularly when inhaled with air, it is important to establish whether, and to what extent, these contaminants are present in the respirable portion of airborne particulates.

Since Sault Ste. Marie had not been included in previous investigations of this kind, this work was intended to provide a preliminary basis for an assessment of the potential health hazards which PAH compounds may present in that area.

ANALYTICAL

Sampling with the use of an Andersen impactor had been carried out on 3 consecutive days (August 23-25, 1977) at 2 locations in Sault Ste. Marie. Both of these locations

were about half a mile downwind from the Algoma Steel Company with one sampling station, "Sampler Head No. 8", being located South East from that Company, in the direction of the prevalent Northwesterly winds, and another station, "Sampler Head No. 7" East from the Company but still in predominantly downwind direction. Each of the 6 sets of Andersen filter samples (from 5 filtration stages per set) included 4 Whatman No. 41 paper filters and 1 glass fibre back-up filter.

The PAH analyses of the submitted 30 Andersen filter samples were preceded by Soxhlet extraction with cyclohexane over a period of 10 hours. The extracts were subsequently concentrated by blowing down with nitrogen gas on a water bath and then were subjected to High-Performance Liquid Chromatography (HPLC) with the use of a "Vydac" reversed-phase column and a mixture of 75% aqueous acetonitrile serving as the liquid phase. By using a fluorescence detector as an in-line detector, the following PAH compounds were quantitatively determined: Benzo(a)pyrene (BaP), benzo(k)fluoranthene (BkF), fluoroanthene, perylene, and benzo(g h i)perylene.

The amounts of PAH compounds determined for each Andersen filtration stage were related to the volume of air sample used and also to the weight of total suspended particulate (TSP). Accordingly, the analytical results are shown in Table 1, expressed in micrograms PAH per 1000 m³ air, and in Table 2, in micrograms PAH per gram TSP.

RESULTS AND DISCUSSION

The analyses of samples taken at 2 locations downwind from the Algoma Steel Company in Sault Ste. Marie showed that the concentrations of total suspended particulate (TSP) as well as of the PAH compounds were only moderately high. Much higher concentration levels in the same general area had been recorded on previous occasions, as determined

by High Volume filter analyses. Nevertheless, the presently reported TSP and PAH levels were sufficiently high to permit the separation of TSP by particle size and quantitation of PAH at each particle size range of the Andersen impactor.

The data shown in Tables 1 and 2 indicated that in all samples the five PAH compounds analyzed were predominantly associated with particles found on the fifth (back-up) filter of the Andersen impactor. These particles were of the "respirable" size range below 1.1 μm . It also became apparent that by far the highest PAH levels were observed during the first two days of sampling at the location of "Sampler Head No. 8". Of all PAH compounds investigated, benzo (g h i) perylene contributed most to the total PAH levels and provided also the remarkable exception (on the second sampling day) by being found at its highest level on the second filtration stage of the Andersen impactor. Particles on this stage are in the 5-7 μm size range and, therefore, are still "respirable".

Particles found on the first filtration stage with sizes of above 7 μm being in the "non-respirable" range, were found to contain only small fractions of the total PAH in each sample. Thus, in line with the other PAH compounds investigated, generally over 90% of the potent carcinogen benzo (a) pyrene (BaP) in each sample was associated with the "respirable" portion of the airborne particulate.

The results from this investigation were also used for comparison with results from a similar study on air particulates from the vicinity of the large steel companies in Hamilton (Report OTC-230177). In this latter study, Andersen filter samples had been taken during a 5-day period at the end of September 1977, while the present study for Sault Ste. Marie covers a 3-day period during August, 1977.

In Table 2, the TSP loadings for each stage of the Andersen impactor are shown as well as their totals for each sample analyzed. A comparison of the average TSP loading from all samples with that obtained from the samples analyzed in the Hamilton study indicated that the average TSP level at Sault Ste. Marie was only half of that at Hamilton during the respective time periods (Table 3).

By contrast to the average TSP levels, the average PAH levels were approximately equal at these two locations. Therefore, there was twice as much PAH per TSP loading in the samples from Sault Ste. Marie than there was in the Hamilton samples (Table 3).

CONCLUSIONS AND RECOMMENDATIONS

- 1) An investigation on the distribution of 5 PAH compounds with particle size in airborne particulate was carried out on samples from Sault Ste. Marie. With moderately high concentration levels of these contaminants in the air samples submitted, the predominant portions of all PAH was clearly associated with particles of the "respirable" size range and, particularly, of the size range below 1.1 μm .
- 2) A previously conducted study on PAH distribution with particle size in the Hamilton area had lead to the same general result by showing those compounds to adhere predominantly to the small "respirable" particles of airborne particulate. Both, Hamilton and Sault Ste. Marie are locations of large steel mills with coke-oven stack gas emissions containing relatively high levels of PAH compounds.
- 3) After these preliminary investigations in both cities had been based on samples collected during a total of only 3 and 5 days, respectively, more extensive studies on this subject appear now appropriate. This may involve confirmation

of the results reported here with samples collected at the same general locations over longer periods of time and including periods of extremes in PAH levels in the atmosphere.

Furthermore, it is suggested that similar investigations be carried out in locations remote from the influence of steel mill operations and in areas with PAH sources other than coke-oven emissions. Such investigations might uncover the adherence of PAH compounds to particle sizes at distributions other than found in this study and, thus might help in the identification of specific emission sources.

TABLE 1

POLYNUCLEAR AROMATIC HYDROCARBONS ON ANDERSEN FILTERS
COLLECTED AT SAULT STE. MARIE STA. 77000

Sampler Head No.	Collection Plate No.	Filter No.	Date 1977	BaP, ug/ 1000m ³ Air	BkF, ug/ 1000m ³ Air	Fluoranthene ug/1000m ³ Air	Perylene ug/1000m ³ Air	B(ghi)P ug/1000m ³ Air
7	1	006	23/8	0.06	0.05	0.02	0.05	0.13
7	2	007	"	0.10	0.08	0.15	0.10	0.34
7	3	008	"	0.12	0.10	0.13	0.17	0.74
7	4	009	"	0.34	0.24	0.20	0.33	0.63
7	5	010	"	0.47	0.43	0.39	0.63	2.87
7		TOTAL		1.09	0.90	0.89	1.28	4.71
7	1	011	24/8	0.12	0.10	0.20	0.13	0.23
7	2	012	"	0.07	0.05	0.15	0.07	0.11
7	3	013	"	<0.01	0.03	0.07	0.03	0.14
7	4	014	"	0.03	0.02	0.08	0.03	0.17
7	5	015	"	0.11	0.07	0.13	0.05	0.45
7		TOTAL		0.34	0.27	0.63	0.31	1.10
7	1	016	25/8	0.05	0.04	0.14	0.04	0.09
7	2	017	"	0.05	0.02	0.12	0.03	0.08
7	3	018	"	n.d.	n.d.	n.d.	n.d.	n.d.
7	4	019	"	0.04	0.02	0.10	0.03	0.20
7	5	020	"	0.08	0.08	0.25	0.07	0.16
7		TOTAL		0.22	0.16	0.61	0.17	0.53
8	1	006	23/8	0.12	0.15	0.16	0.16	0.34
8	2	007	"	0.20	0.15	0.21	0.20	0.45
8	3	008	"	0.94	0.21	0.21	0.36	1.48
8	4	009	"	0.53	0.37	0.14	0.52	1.14
8	5	010	"	0.51	0.89	0.23	1.41	4.38
8		TOTAL		2.30	1.77	0.95	2.65	7.79
8	1	011	24/8	0.09	0.13	0.17	0.14	0.45
8	2	012	"	0.34	0.27	0.12	0.35	10.9
8	3	013	"	0.64	0.57	0.28	0.91	2.72
8	4	014	"	1.28	0.85	0.33	1.26	2.18
8	5	015	"	0.77	1.37	1.10	1.72	3.28
8		TOTAL		3.12	3.19	2.00	4.38	19.53

n.d. = Not Determined

TABLE 1

POLYNUCLEAR AROMATIC HYDROCARBONS ON ANDERSEN FILTERS
COLLECTED AT SAULT STE. MARIE STA. 77000

Sampler Head No.	Collection Plate No.	Filter No.	Date 1977	BaP, ug/ 1000m ³ Air	BkF, ug/ 1000m ³ Air	Fluoranthene ug/1000m ³ Air	Perylene ug/1000m ³ Air	B(ghi)P ug/1000m ³ Air
8	1	016	25/8	0.02	0.02	0.07	0.02	<0.01
8	2	017	"	0.02	0.01	0.03	0.01	0.03
8	3	018	"	0.03	0.02	0.05	0.02	<0.01
8	4	019	"	0.01	0.01	0.05	0.01	<0.01
8	5	020	"	<0.01	<0.01	<0.01	<0.01	<0.01
8		TOTAL		0.09	0.07	0.21	0.07	0.07

TABLE 2

POLYNUCLEAR AROMATIC HYDROCARBONS ON ANDERSEN FILTERS
COLLECTED AT SAULT STE. MARIE STA. 77000

Sampler Head No.	Collection Plate No.	Filter No.	TSP ug/ m ³ Air	Date 1977	BaP ug/g TSP	BkF ug/g TSP	Fluoranthene ug/g TSP	Perylene ug/g TSP	B(ghi)P ug/g TSP
7	1	006	19.7	23/8	3.07	2.51	0.77	2.79	6.76
7	2	007	12.3	"	7.96	6.22	12.6	8.17	27.8
7	3	008	3.4	"	37.0	30.8	38.4	50.9	220
7	4	009	6.2	"	54.4	38.9	32.6	52.5	101
7	5	010	14.2	"	33.3	30.4	27.3	44.0	202
7		TOTAL	55.8		135.73	108.83	111.67	158.36	557.56
7	1	011	30.4	24/8	3.98	3.44	6.45	4.32	7.46
7	2	012	4.3	"	16.2	11.2	34.0	15.3	25.9
7	3	013	8.3	"	<0.01	3.46	8.09	3.86	16.6
7	4	014	3.1	"	11.0	6.10	25.6	8.66	52.7
7	5	015	5.0	"	22.5	13.6	25.7	10.4	89.9
7		TOTAL	51.1		53.69	37.8	99.84	42.54	192.56
7	1	016	11.9	25/8	4.16	3.60	12.1	3.01	7.80
7	2	017	7.0	"	7.50	3.46	16.5	4.86	12.0
7	3	018	7.5	"	n.d.	n.d.	n.d.	n.d.	n.d.
7	4	019	4.6	"	7.64	5.29	20.8	6.36	42.7
7	5	020	4.3	"	18.2	17.8	58.0	15.9	373
7		TOTAL	35.3		37.5	30.15	107.4	30.13	435.5
8	1	006	65.1	23/8	1.92	2.23	2.53	2.50	5.29
8	2	007	34.7	"	5.64	4.26	5.98	5.79	13.1
8	3	008	20.0	"	47.0	10.6	10.3	17.9	73.7
8	4	009	13.6	"	39.3	27.2	10.2	38.2	83.7
8	5	010	30.6	"	16.6	29.1	7.59	46.0	143
8		TOTAL	164.0		110.46	73.39	36.6	110.39	318.79
8	1	011	73.2	24/8	1.20	1.74	2.32	1.92	6.14
8	2	012	37.4	"	9.11	7.25	3.24	9.27	291
8	3	013	26.9	"	23.8	21.1	10.3	34.0	101
8	4	014	17.2	"	74.2	49.3	19.2	73.3	126
8	5	015	36.7	"	20.9	37.4	30.1	46.8	89.3
8		TOTAL	191.4		129.21	116.79	65.16	165.29	613.44

n.d. - Not Determined

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TABLE 2

POLYNUCLEAR AROMATIC HYDROCARBONS ON ANDERSEN FILTERS
COLLECTED AT SAULT STE. MARIE STA. 77000

Sampler Head No.	Collection Plate No.	Filter No.	TSP ug/ m ³ Air	Date 1977	BaP ug/g TSP	BkF ug/g TSP	Fluoranthene ug/g TSP	Perylene ug/g TSP	B(ghi)P ug/g TSP
8	1	016	16.7	25/8	1.45	1.21	3.90	1.11	<0.01
8	2	017	5.9	"	2.93	2.43	5.30	2.44	4.68
8	3	018	7.0	"	4.91	2.72	7.00	2.73	<0.01
8	4	019	3.6	"	2.37	3.28	12.9	3.51	<0.01
8	5	020	3.1	"	<0.01	<0.01	<0.01	<0.01	<0.01
8		TOTAL	36.3		11.67	9.65	29.11	9.80	4.72

TABLE 3

COMPARISON OF AVERAGE TSP AND PAH LEVELS

	Sault Ste. Marie (6 Air Samples/ 3 days) ug/1000 m ³	Hamilton (7 Air Samples/ 5 Days)ug/1000 m ³
TSP	89000	163000
BaP	1.19	0.92
BkF	1.06	0.94
Fluoranthene	0.88	n.a.
Perylene	1.48	2.09
B(g h i)perylene	5.62	3.12
Coronene	n.a.	1.37

n.a. = Not available



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